

Implications of including freshwater mussel toxicity data in water quality criteria derivation datasets

Tom Augspurger, USFWS, Raleigh, NC

Jim Dwyer, USFWS, Columbia, MO

Chris Ingersoll, USGS, Columbia, MO



Presented at the 27th annual meeting of the Society of Environmental Toxicology and Chemistry, Montreal Quebec, November 2006

Freshwater Mussels

Nearly 300 species in North America

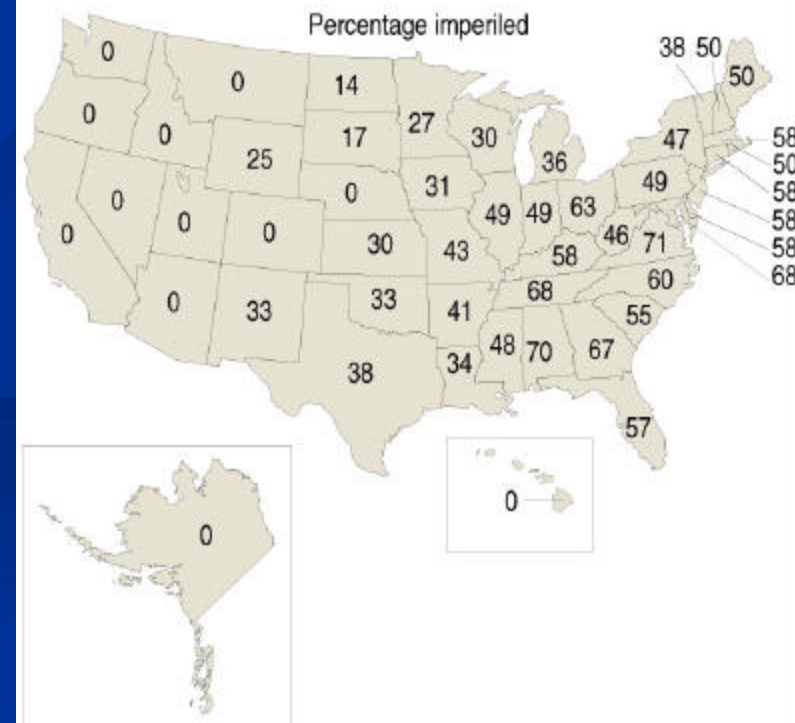
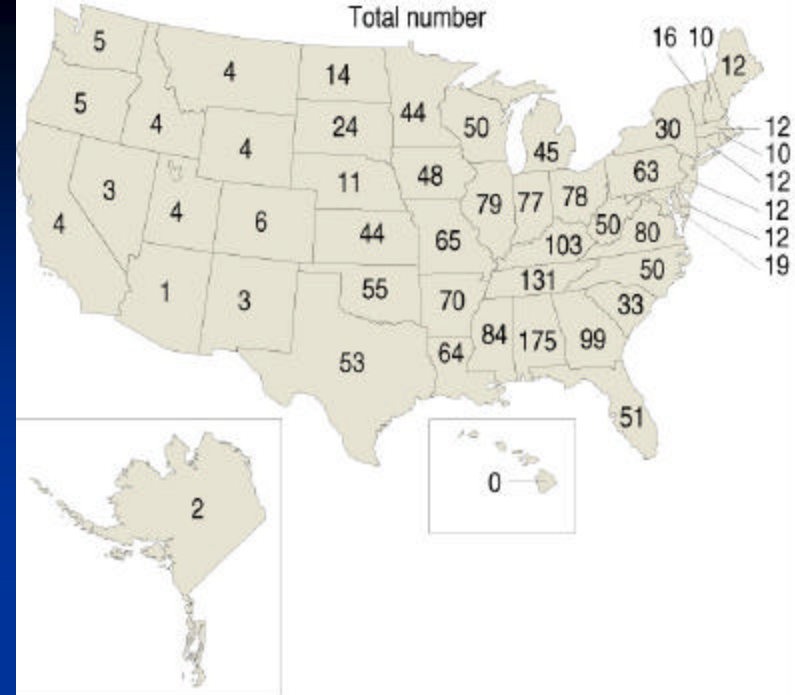
Occur in every State and all Canadian Provinces

35 extinct, 70 listed as threatened or endangered



Number of freshwater
mussel species
historically known to
occur within each state
and the percentage
classified as imperiled

Williams and Neves 1995





Unio Gallery

Juvenile and adult mussels are benthic filter feeders
Exposed to pollutants in water and sediment

Objectives

- 1) Determine if select US ambient water quality criteria (WQC) would be appreciably influenced if freshwater mussel toxicity data were included
- 2) Help prioritize research needs for mussel recovery

Methods

1. Retrieve toxicity data for freshwater mussels for pollutants that have EPA WQC criteria
2. Cull dataset based on consensus list of test acceptability requirements in the new ASTM standard (E2455-06)



Designation: E 2455 – 06

Standard Guide for
Conducting Laboratory Toxicity Tests with Freshwater
Mussels¹

Methods

3. Calculate Genus Mean Acute Values (GMAV) per EPA guidelines
4. Add mussel GMAVs to criteria database
5. Re-rank GMAVs and assess mussel ranks in genus sensitivity distributions

GUIDELINES FOR DERIVING NUMERICAL NATIONAL WATER QUALITY CRITERIA
FOR THE PROTECTION OF AQUATIC ORGANISMS AND THEIR USES

by

Charles E. Stephan, Donald I. Mount, David J. Hansen, John H. Gentile,
Gary A. Chapman, and William A. Brungs

U.S. ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF RESEARCH AND DEVELOPMENT
ENVIRONMENTAL RESEARCH LABORATORIES
DULUTH, MINNESOTA
NARRAGANSETT, RHODE ISLAND
CORVALLIS, OREGON

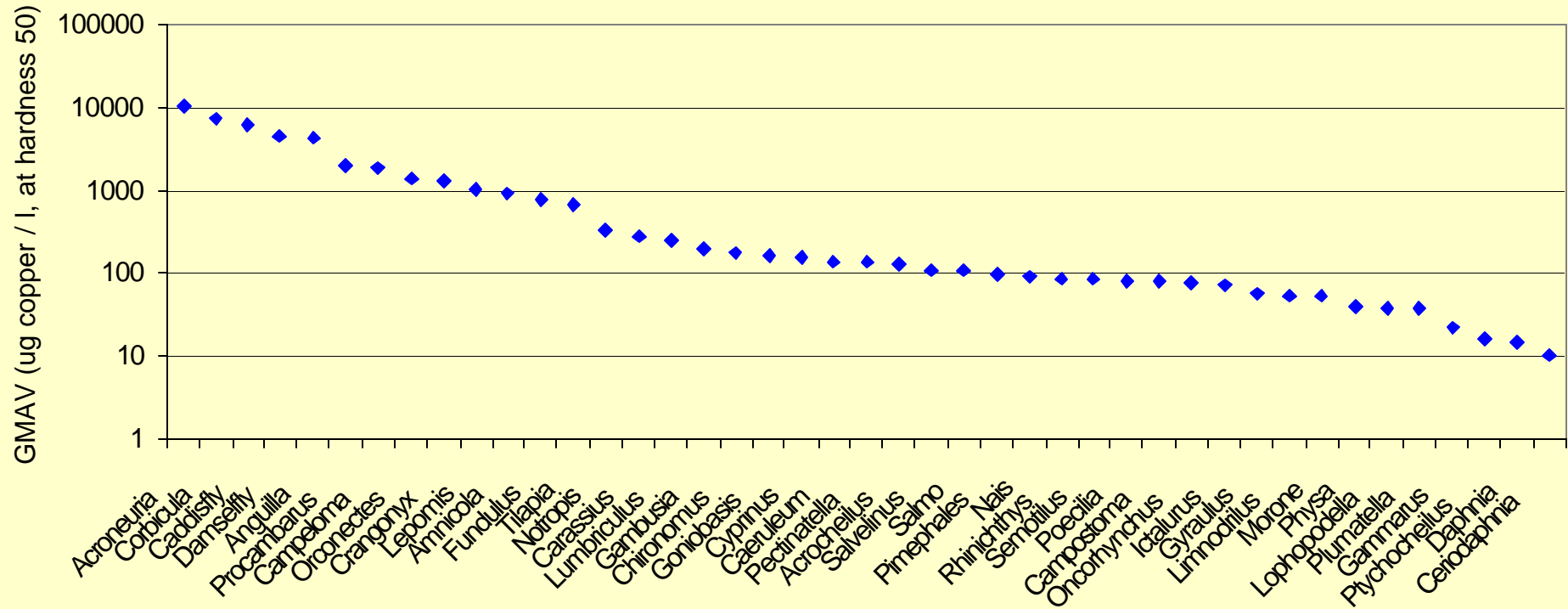
Test Acceptability

- Test duration
 - 24-hr glochidia (unless species life history indicates longer is appropriate)
 - 96-hr juvenile
- ≥ 90% survival in controls
- In vivo transformation of glochidia
- Acceptable water chemistry and measured toxicant concentrations

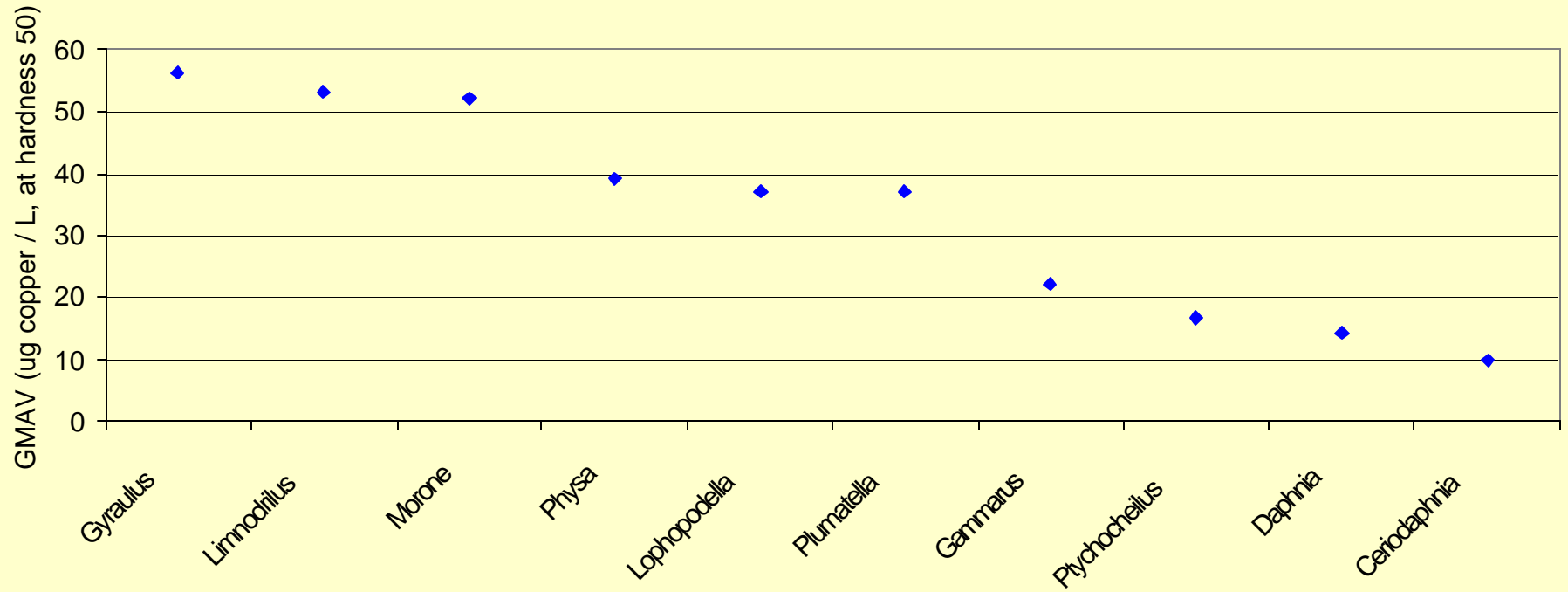
For example...Copper

- 217 mussels tests retrieved
- 126 of those meet test duration recommendations of ASTM
- 115 of those 126 tests met $\geq 90\%$ control survival criteria
 - 20 species in 14 mussel genera

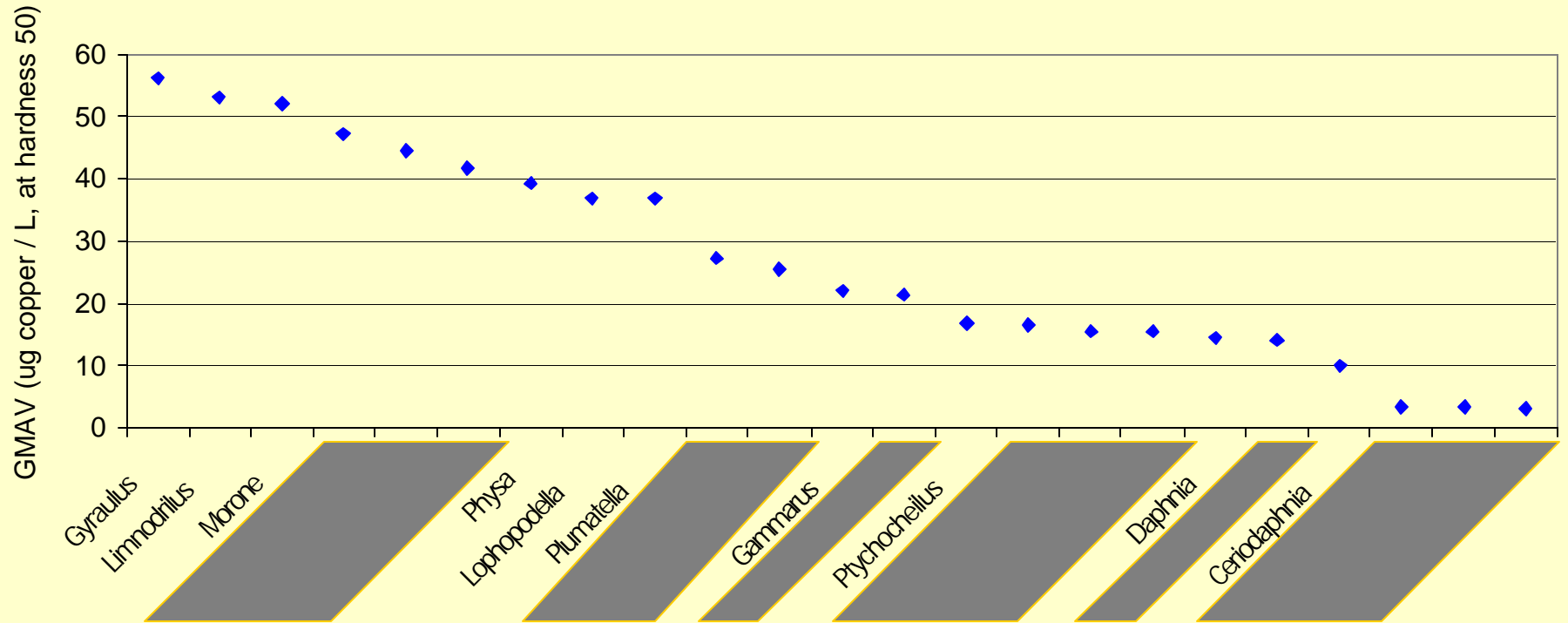
Ranked GMAVs for Copper (1996 AWQC Update)



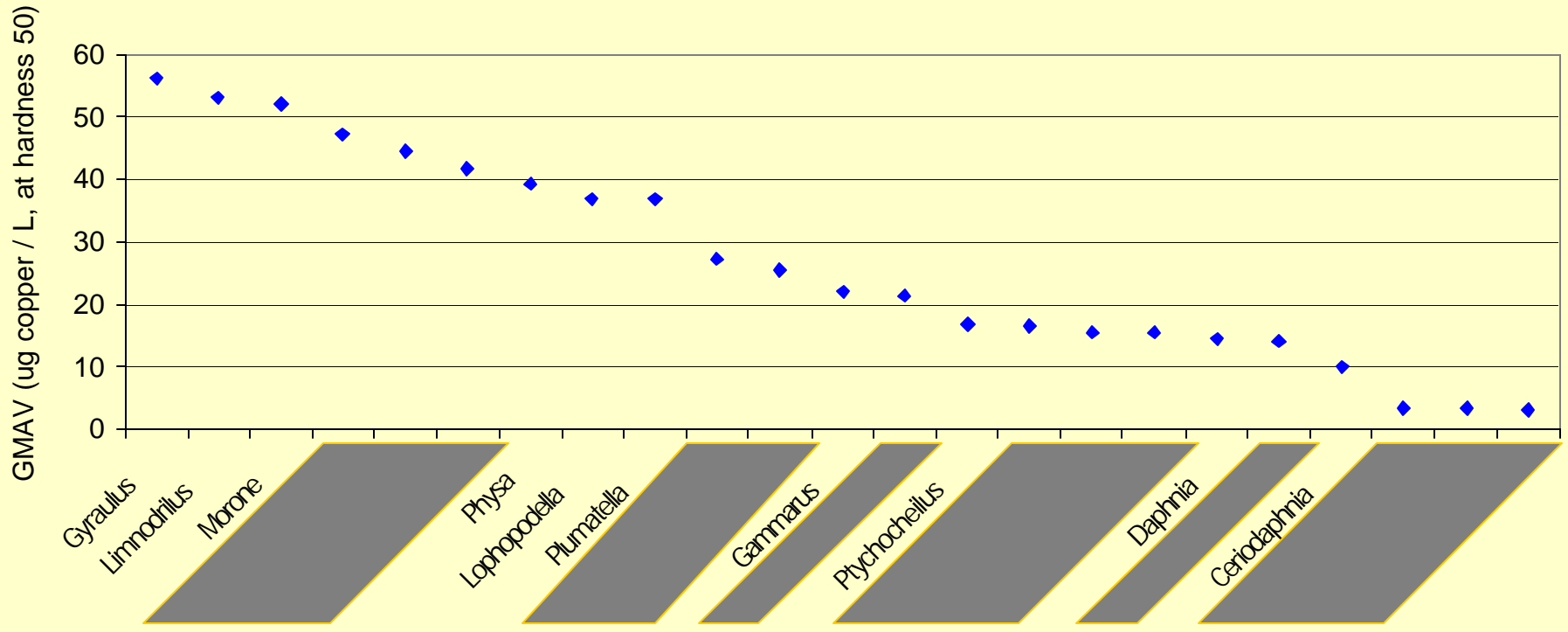
**Ranked GMAVs for Copper (1996 AWQC Update):
10 most sensitive taxa in the dataset**



Ranked GMAVs for Copper (1996 AWQC Update):
adding data for mussel genera (shaded)



Ranked GMAVs for Copper (1996 AWQC Update):
adding data for mussel genera (shaded)

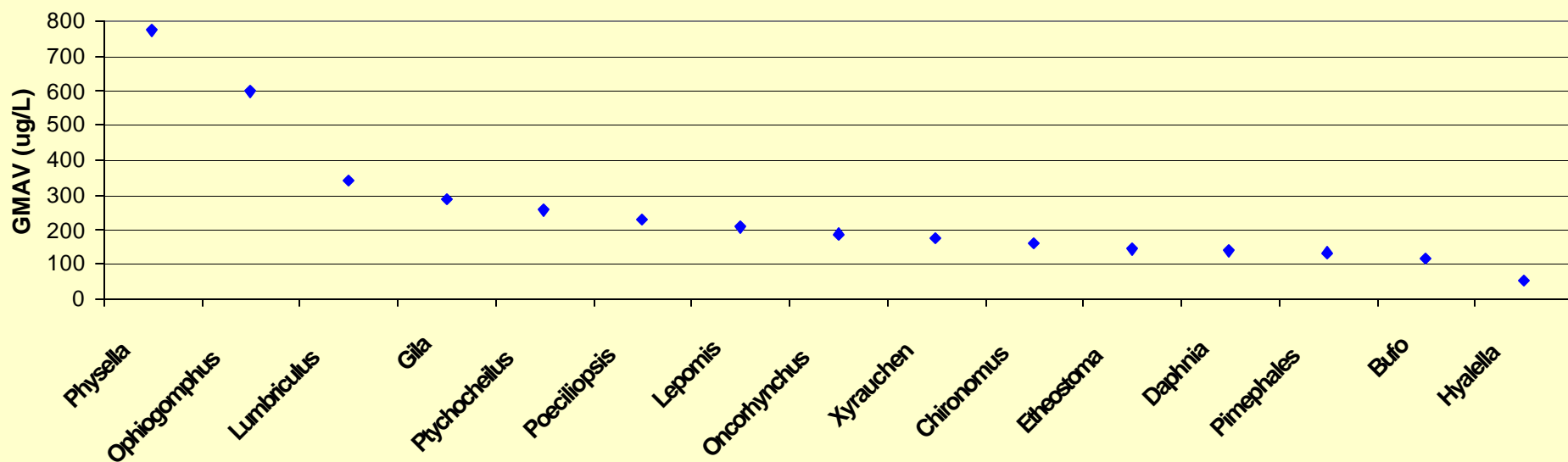


Mussels 4 of the 5 most sensitive genera

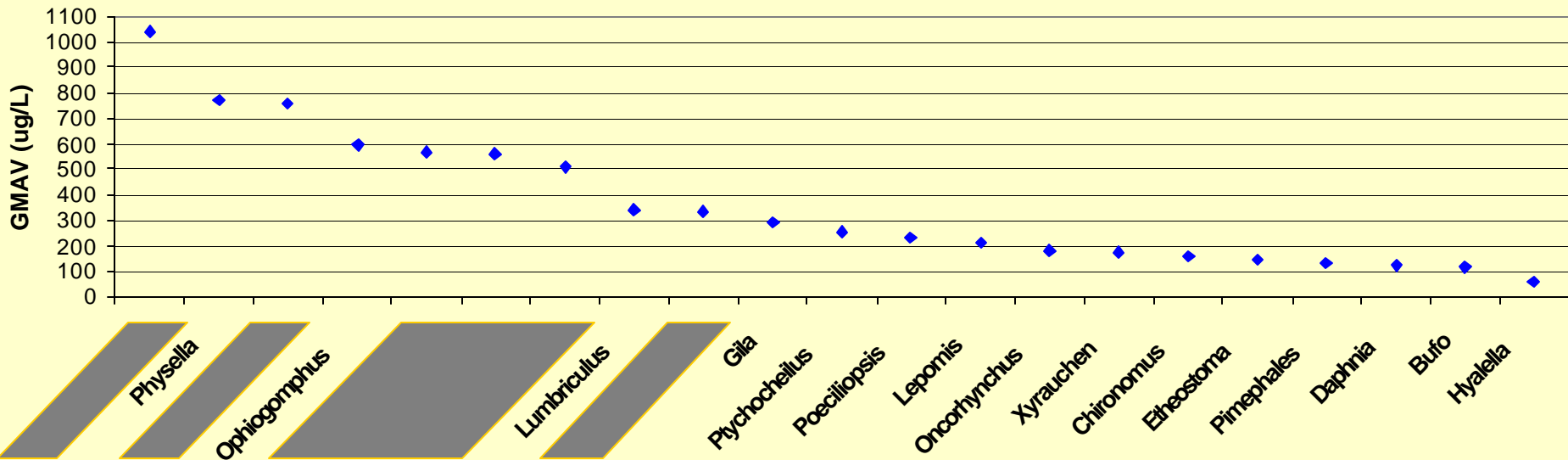
For example...Nonylphenol

- 28 mussels tests retrieved
- 14 of those meet test duration recommendations of ASTM
- 10 of those 14 met $\geq 90\%$ control survival criteria
 - 7 species in 6 mussel genera

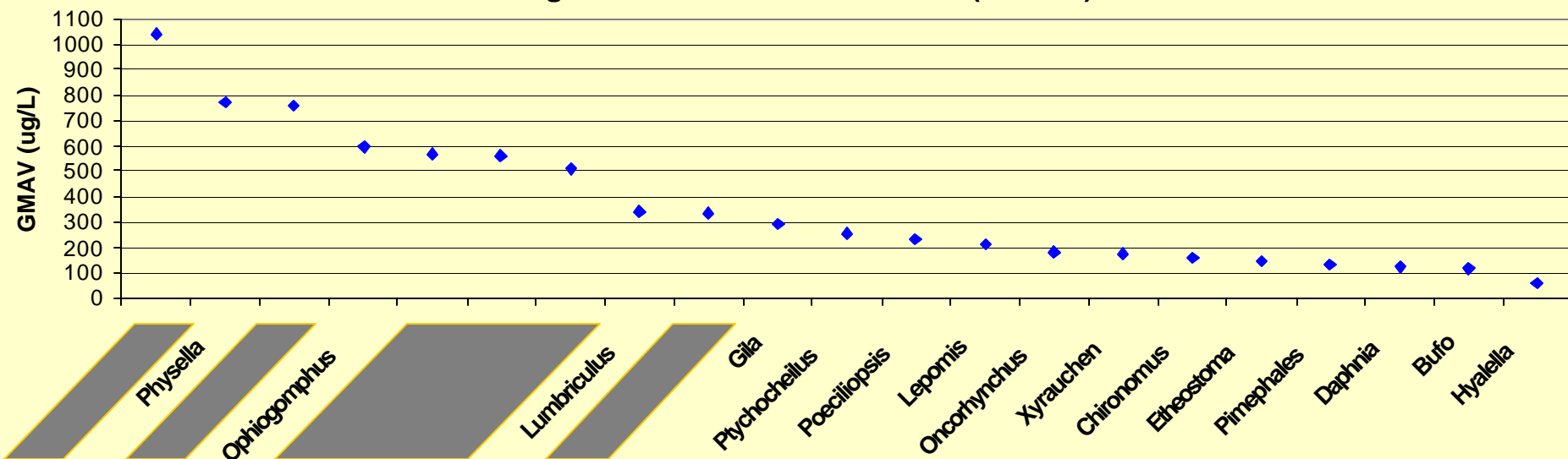
Ranked GMAVs for Nonylphenol (2005 criteria document dataset)



Ranked GMAVs for Nonylphenol (2005 criteria document dataset),
adding data for freshwater mussels (shaded)



Ranked GMAVs for Nonylphenol (2005 criteria document dataset),
adding data for freshwater mussels (shaded)



No mussels among 10 most sensitive genera

Summary

Criteria	GMAVs in WQC	GMAVs w/Mussels	Lowest Mussel Rank (1 = Most Sensitive)
Ammonia	34	42	1 (1, 2, 3, 4)
Atrazine (draft)	17	21	15
Chlorine	28	35	2 (2, 5, 9, 14)
Chlorpyrifos	15	16	13
Copper	43	57	1 (1, 2, 3, 5)
Diazinon	20	21	21
Mercury	29	30	10
Nonylphenol	15	21	13
PCP	32	37	17

1999 Ammonia Criteria Revision



United States
Environmental Protection
Agency

Office of Water
4304

EPA-822-R-99-014
December 1999

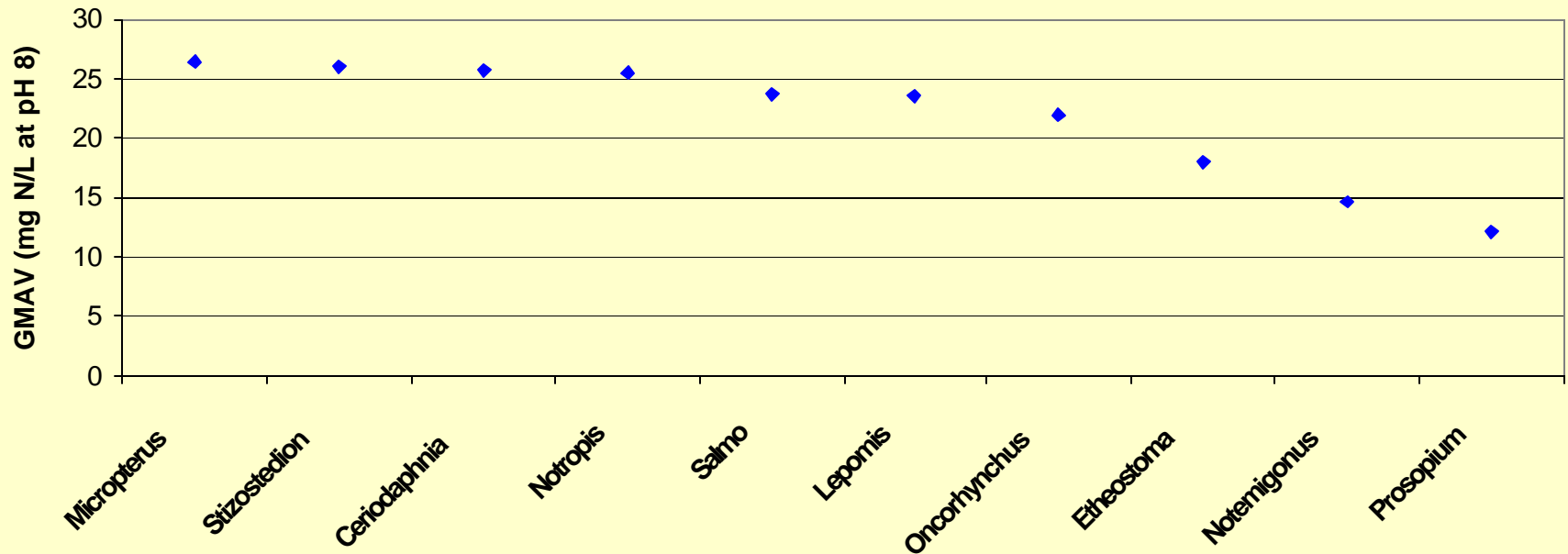
1999 Update of Ambient Water Quality Criteria for

Ammonia

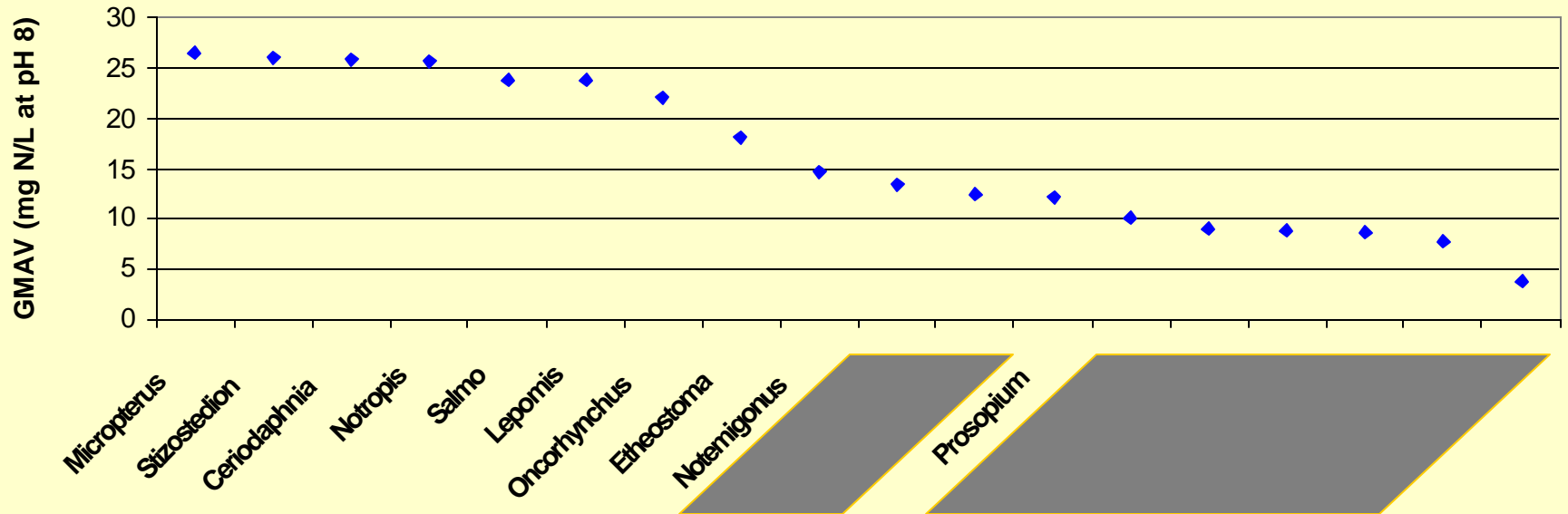
Supersedes 1998 Update

No data for freshwater
mussels

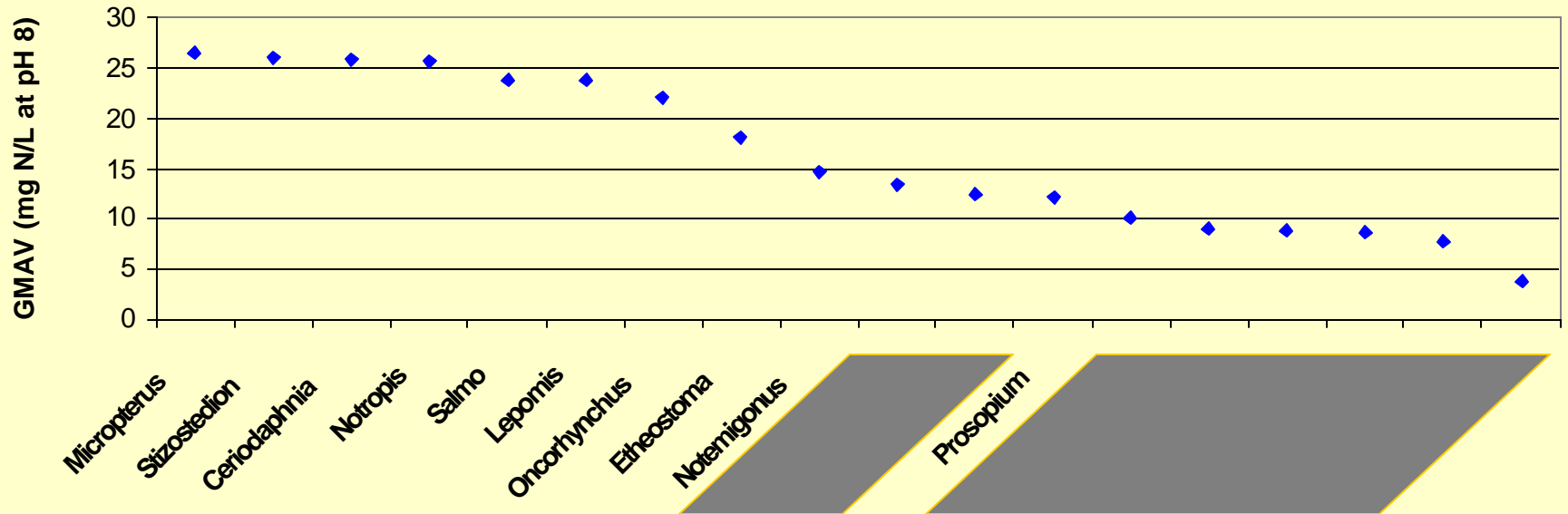
Ranked GMAVs for Total Ammonia
(10 most sensitive taxa in the 1985 water quality criteria dataset)



Ranked GMAVs for Total Ammonia
(10 most sensitive taxa in the 1985 water quality criteria dataset),
adding data for freshwater mussels (shaded)

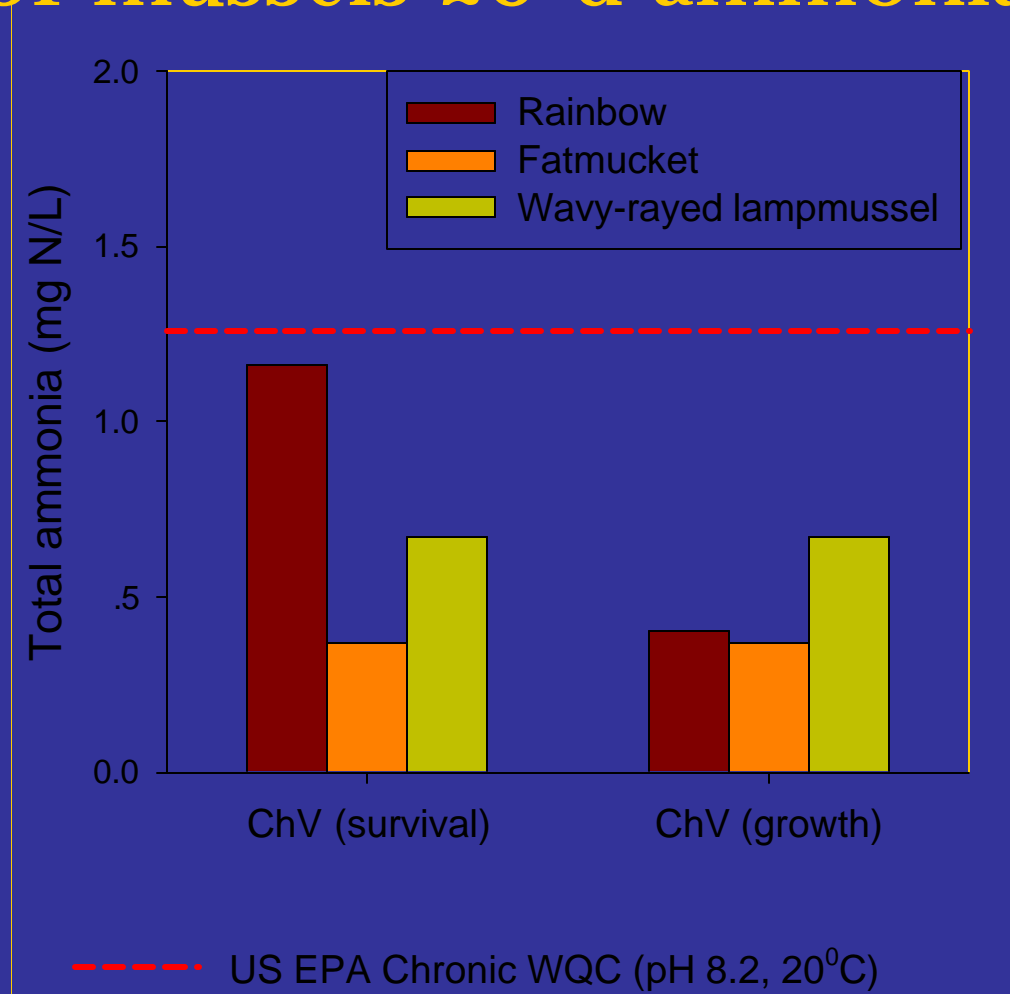


Ranked GMAVs for Total Ammonia
(10 most sensitive taxa in the 1985 water quality criteria dataset),
adding data for freshwater mussels (shaded)



Mussels consistently among the most sensitive genera

Chronic values for survival and growth of mussels 28-d ammonia tests



What's it mean?

- Mussels routinely rank among the more sensitive organisms to ammonia and copper

What's it mean?

- Mussels routinely rank among the more sensitive organisms to ammonia and copper
- Mussels of intermediate sensitivity to chlorine

What's it mean?

- Mussels routinely rank among the more sensitive organisms to ammonia and copper
- Mussels of intermediate sensitivity to chlorine
- Mussels relatively tolerant of other pollutants evaluated here

What's it mean?

- When compared with other taxa, no one species, genus, family most sensitive to all chemicals all of the time

What's it mean?

- When compared with other taxa, no one species, genus, family most sensitive to all chemicals all of the time
- Mussels sensitive frequently enough to warrant special consideration

Status

- Agreement that mussel toxicity tests conducted according to ASTM standard can be used in WQC derivation (USEPA 2005 workshop)

Proceedings Summary Report

Mussel Toxicity Testing Procedures Workshop

August 23-24, 2005

Crowne Plaza-Chicago Metro Hotel, Chicago, IL

Prepared for:



United States Environmental Protection Agency
Office of Science and Technology
Health and Ecological Criteria Division

<http://www.epa.gov/waterscience/criteria/ammonia>

Recommendations

Research needs:

- Longer chronic tests
- Additional sublethal endpoints, like reproduction
- Expand this comparative toxicology database to help prioritize pollutants at field sites (lead, cadmium and zinc data emerging)

Recommendations

- Add freshwater mussels to the minimum dataset requirements for criteria development

Note: mollusks and amphibians considered as additional dataset requirements in 1990's

GUIDELINES FOR DERIVING NUMERICAL NATIONAL WATER QUALITY CRITERIA
FOR THE PROTECTION OF AQUATIC ORGANISMS AND THEIR USES

by

Charles E. Scepahn, Donald I. Mount, David J. Hansen, John H. Gentile,
Gary A. Chapman, and William A. Brungs

U.S. ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF RESEARCH AND DEVELOPMENT
ENVIRONMENTAL RESEARCH LABORATORIES
DULUTH, MINNESOTA
NARRAGANSETT, RHODE ISLAND
CORVALLIS, OREGON

Thanks

USGS Columbia Environmental Research Center

Ning Wang

USFWS

Sara Ward, Cindy Kane

North Carolina State University

Robert Bringolf, Greg Cope

USEPA – Office of Water

“How did these beautiful rainbow-tints get into the shell of the fresh-water clam, buried in the mud at the bottom of our dark river?”

Thoreau



M. C. Barnhart